National Security Education Center

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Information Science and Technology Center Seminar

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Mechanical Engineering Department
Worcester Polytechnic Institute

"Search and Classification Decision-Making for Mobile Sensor Coverage of Large-Scale Domains"

Wednesday, January 20, 2010
3:00 - 4:30 PM
TA-3, Bldg. 1690, Room 102 (CNLS Conference Room)

Abstract: In surveillance, exploration, environmental monitoring, and search and rescue/destroy, one is typically faced with a situation where a very large-scale domain needs to be surveyed using limited sensory resources. Such limitations include limited sensory ranges and a limited number of sensors. In these situations, any available immobile sensors will not be capable of covering the entire domain. Hence, one needs to mount sensors on mobile platforms and develop navigation algorithms that seek to survey the entire domain over time. This is the search problem. In addition to the search problem, the mobile platform is also required to perform other tasks such as classification and tracking of found objects of interest, or the return to a base station for refueling, among others. These tasks, in the worst case scenario, are competing. In other words, they cannot all be performed at the same time. This introduces the problem of task decision-making: Which task should the mobile platform execute at any given moment of time? In this work, I will assume that the only two tasks to be executed are search and classification, which are two competing tasks since a mobile platform can perform either the search task (which requires mobility) or the classification task (which requires constraining the motion of the platform to that of the object being classified), but not both at the same time. This is a very critical decision as choosing one option over the other may result in missing other, more important objects not yet found, or missing the opportunity to satisfactorily classify a found critical object. Building on previous deterministic-based work, in this talk I will present Bayesian-based search versus classification decision-making criteria that result in guaranteed detection and classification of all objects in the domain. I will first present the results for a single mobile sensor platform and will then generalize the result to the centralized and decentralized (with intermittent communications) cases for multiple cooperating mobile platforms. I will briefly present some more recent unpublished work on the use of cost-aware Bayesian sequential risk analysis to address the same problem. I will conclude by presenting some recent results on applying some of these results to future space-augmented space surveillance networks.

Biography: Islam Hussein has been an Assistant Professor of Aerospace Engineering at Worcester Polytechnic Institute since 2006. From 2005 to 2006, he held a postdoctoral research associate position at the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign. He was awarded the PhD degree in Aerospace Engineering in 2005 and the MSc degrees in Aerospace Engineering and Applied Mathematics in 2002 from the University of Michigan in Ann Arbor. He received his BSc degree in 2000 from the American University in Cairo. Professor Hussein is the recipient of a 2009 ASEE/AFRL Summer Faculty Fellowship Award where he conducted research on Space Surveillance at the Air Force Research Laboratory in Albuquerque, NM.

His research interests are in the areas of (1) decentralized information management, decision-making and control in highly distributed, dynamic complex sensor networks, (2) space situational awareness, (3) behavioral evolution in networked systems, and, in general, (4) nonlinear constrained dynamics and control. In the past, he has worked on the design and control of multiple satellite interferometric imaging systems (PhD thesis) as well as nonlinear design and control of virtually tethered (i.e., using electromagnetic tethers) multi-satellite systems. Professor Hussein directs the Coordination and Navigation of Multi-Vehicle Systems Laboratory at WPI, where his research team is building two autonomous underwater vehicles and two autonomous miniature boats to be used to test his theoretical research results on cooperative multi-vehicle persistent surveillance over large-scale domains.

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